

2007

Learning Through Multimedia Construction: A Complex Strategy

Christine Brown
cbrown@uow.edu.au

Follow this and additional works at: <https://ro.uow.edu.au/edupapers>



Part of the [Education Commons](#)

Recommended Citation

Brown, Christine: Learning Through Multimedia Construction: A Complex Strategy 2007.
<https://ro.uow.edu.au/edupapers/1138>

Learning Through Multimedia Construction—A Complex Strategy

CHRISTINE BROWN
University of Wollongong
Australia
christine_brown@uow.edu.au

Multimedia construction is a complex and theoretically valid process for developing higher order thinking that can be implemented as a teaching activity and optionally associated with formal assessment in many ways. This article explores the associated learning strategy—learning through multimedia construction, through research and reflective analysis of two class cases that feature learners from primary school and tertiary age ranges.

The lecturer/researcher develops awareness of the complexity of group interactions, resource implications, the critical design of meaningful activities, appropriate assessment tasks and assessment criteria, and the importance of task and product ownership.

Each case is presented in descriptive text accompanied by analysis using two recent activity/learning design models. A key aim is to inform those who wish to engage students in such activities of some of the critical factors that maximise the strengths of this strategy and inform meaningful negotiation of the potential pitfalls.

As individual educators or institutionally based teams evaluate the design of learning environments, they have the ability to closely monitor how many students use information and communication technology (ICT) tools

and apply this knowledge to improve the design of future assessment tasks. Educators can adopt the language of learning design to articulate the richness of task design within the complexity of blended formal learning environments that differ across faculties and institutions within Higher Education. Global forces are shaping a future where individuals are less likely to have complete design freedom to create the scaffolding of a fledgling learning environment within the plethora of ICT tools networks and communities. The tension between what is most pedagogically desirable and what is achievable within technical, social, cultural, financial, and political constraints remains as tangible as ever, and highlights the need for design teams with good negotiation skills. It is important that different authors give voice to the various perspectives so that key solutions to ill-structured learning design problems can be determined from a broad knowledge base that reflects consideration of multiple perspectives.

From the pedagogical perspective, in a drive to increase higher order learning outcomes and shift curricula away from a content to a problem or task-based learning design, Oliver (2004) suggested re-engineering objectives into an outcomes-based approach that focuses on performance and capabilities. Many of the assessments tasks that align to this place more emphasis on a portfolio approach and self and peer assessment. Given the significant role of ICT in the global reach of many tertiary courses, and the preference for higher order thinking discussed by Oliver, it is timely to revisit the fundamentals of some key learning and teaching strategies that potentially support this direction by not only addressing targeted student learning outcomes within discrete subjects or courses, but also reaching beyond with the aid of portfolios to the concept of student or teacher as lifelong learner.

One such strategy that provides students and teaching staff with key skills and artefacts for ongoing electronic portfolio compilation that is shaped by personally meaningful goals is learning through multimedia construction. This article analyses some class experiences of multimedia construction in the mid 1990s—a period when the hype of multimedia construction was at a peak, using some of the current language of learning design. The aim is to identify the highlights and issues associated with the strategy of learning through multimedia construction to add to the body of knowledge informing tertiary educators who either want to design small discrete and possibly authentic learning episodes within a subject or course, or those who are deciding at a more strategic level within a program of study on the structure and strategies associated with student-driven electronic portfolios that span a study program and beyond.

Conceptually electronic portfolio tools provide their users with the superglue to construct multiple representations of past achievements according to the needs of a defined target audience. From the author's experience, the outcome—a particular portfolio compilation and its associated artefacts, belies the depth of learning associated with artefact analysis, selection, and creative construction to present a cohesive interface. The primary purpose behind portfolio construction varies, from the desire to develop deeper conceptual understanding of past achievements or create an impression to more structured formats that might unpack a process, illustrate a skill set, demonstrate diversity and flexibility, or simply present the required elements for a job application.

It seems inevitable that ICT tools and systems including those associated with electronic portfolio construction will continually change—a fact that to some serves as a positive trigger to construct and reconstruct new representations of personal and team accomplishments in a lifelong approach to learning. Some of the negative aspects of constant technological change are pragmatic and more compelling. First, the organization, ownership, and meta-tagging protocols associated with file storage—how long can we keep saying we can fit more on less, where does that “less” reside, how do we access it and who owns it? Second, the availability of user driven flexible tools that allow access to construct new representations—the interoperability required for portfolio construction tools to locate and connect artefacts in different storage banks. Third, the continuity or transferability of file formats of particular artefacts or objects—the wave of redevelopment initiated by messages such as “the application is no longer available to open this file,” or “the application is no longer compatible with the new operating system.”

The list of negative aspects appears overwhelming in its complexity and touches upon the fundamental tension between creative freedom and the need for standards, yet some might argue that true creativity is exhibited within conditions that impose tight constraints. This article adopts the latter view as it argues the benefits of multimedia construction as a valid and worthwhile learning experience however brief and constrained, once the task designers are aware of critical factors.

The author begins with a brief discussion of the theoretical basis of multimedia construction as a learning strategy and two simple design language models that have been chosen to describe class experiences in a generic manner for comparison and contrast. The literature pertaining to multimedia construction is from a period prior to the conduct of classes. It represents the authentic context of the author when the classes were conducted.

THEORETICAL BACKGROUND

Multimedia Construction as a Learning Strategy—Historic Viewpoint

In the 1990s *interactive multimedia* was a new form of expression, associated with terms such as hypermedia and hypertext. Although it fostered visual literacy (Liebhold, 1990) it could also increase cognitive load on learners (Oren, 1990) and demanded new production and design skills of teachers (Biros, 1990; Campbell & Hanlon, 1990). If teachers and students were to learn collaboratively, then teachers would need to make a philosophical shift in their approach to teaching (Bradsher, 1990; Hofmeister, 1990; Stebbins, 1990; Papert, 1991).

A constructivist view of learning supported the concept of situated cognition (Brown, Collins & Duguid, 1989) and the teaching method of cognitive apprenticeship. Teachers were to spontaneously model the problem-solving process, include error handling and construct multiple perspectives. A collaborative learning environment should allow learners to experience the rigorous process of developing and evaluating arguments to justify their different perspectives (Bednar, Cunningham, Duffy, & Perry, 1991). Teachers could not be regarded as technicians following some formula (Papert, 1991, p. 18), since constructivist principles placed learners in a central position driving the process.

Within this frame of reference, a constructivist approach, put interactive technologies in the hands of student producers. These technologies could theoretically provide a wealth of thinking and knowledge construction tools to allow learners to represent knowledge in diverse media and structures. Individuals could freely express developing ideas in their preferred medium at a particular point in their understanding. The limiting factors were very practical—access to appropriate equipment, the constructor's skills to fully use software capabilities, their ability to compose or edit media resources and their creative imagination orchestrating media within a software environment. Wilson (1993) acknowledged the power of developing hypermedia products to gain expertise in the associated knowledge domain. Hypertext tools allowed students to create nonlinear structures with conceptual organisation. The learning potential lay in the information processing that occurred along the way.

Nix (1990) introduced the novel concept of dignity in association with computers—student freedom to consider process and feelings, and to be unpredictable in a creative way. Nix placed emphasis on student self-expression, saw the computer as “decentred participant” and described an environ-

ment that featured aesthetics, social interaction, humour, and much student personality. Computer-related activities were part of a range of other activities, and a different genre of computer use was proposed, where:

The computer was a means for bringing together what the students were doing, and of presenting what they were doing in a manner that could be interacted with, enjoyed, and discussed by others. The computer was a means for enabling a focus on how to express the ideas being developed with each project. (Nix, 1990, p. 160)

The adoption of computers by teachers was not a neutral event (Durrell, 1990), and both teachers and students needed to come to terms with such technology on their own level. Creativity and right hemispheric preference could be fostered by a *process* focus (Sanders & Sanders, 1984), and students could develop deep conceptual structures (Wilson, 1993), provided the cognitive load of using the software tools was not too great (Kacmar, 1993). In contrast, given the emphasis on *product* construction, students gained external motivation, knowledge of a target audience, and they were able to hone content knowledge through the media editing and selection process (Beichner, 1994). It was possible to balance process and product if the computer was “decentred,” providing one of many classroom activities in the broad process, and orchestrating the overall product to share with others (Nix, 1990). The literature suggested that allowing students to drive the multimedia construction process was theoretically justified to promote deep learning.

Design Language—Learning Designs (Australian Universities Teaching Committee [AUTC] Framework)

In the AUTC funded project: *Information and Communication Technologies (ICTs) and Their Role in Flexible Learning* (<http://www.learningdesigns.uow.edu.au/index.html>) Agostinho, Oliver, Harper, Hedberg, and Wills (2002) defined learning design as “a variety of ways of designing student learning experiences, that is, the sequence of activities and interactions.” They used geometric shapes to represent sequences of tasks or activities (squares), resources (triangles), and supports (circles) in a visual communication of the learning design within a timeframe. Figure 1 illustrates a visual sequence from the AUTC website that has two concurrent activities at one point:

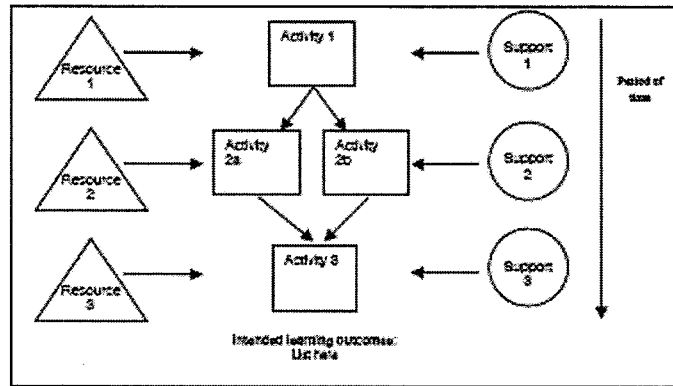


Figure 1. Use of geometric shapes to denote resources, activities, and support (Learning Design Site)

Within the project, feedback on the evaluation instrument (designed by the team to identify high quality ICT-based learning designs) from external evaluators suggested they were unable to fully comprehend the case context, as they were not able to view the richness of the case including such artifacts as student work.

The technique used by the AUTC Learning Designs project team to represent a class learning design case has been adopted by the author who has full knowledge of the classes from the perspective of designer/teacher/researcher. In addition, the geometric shapes of the visual display have been adapted to indicate additional features—the source of the resource or support (whether teacher or student generated) is shown by shape outline pattern; the items related to a particular task are related by fill colour; and the tasks are shown at the point of submission, acknowledging that students may be working on all activities simultaneously from the outset (shown by horizontal placement along the timeline). Time is displayed on the horizontal axis to permit the display of a greater number of concurrent activities within a fixed page width. Figure 2 illustrates the revised key developed by the author to accompany a subject/course learning design timeline.

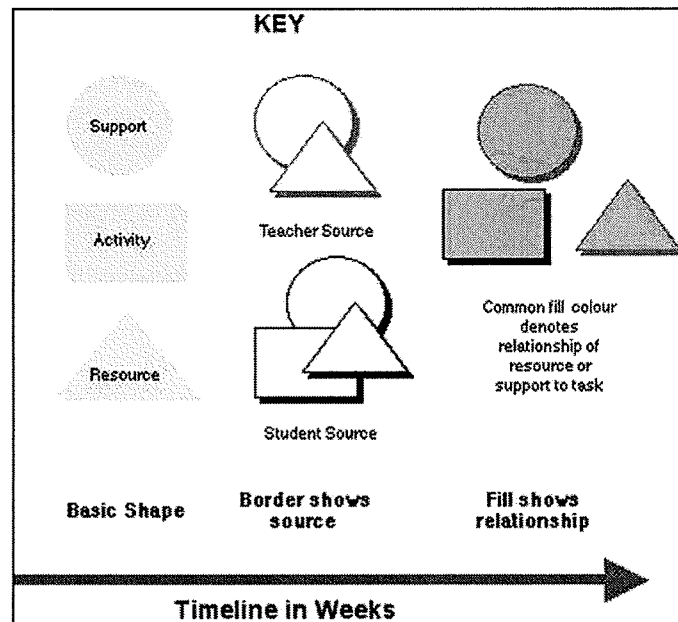


Figure 2. Author's symbol protocol derived from AUTC Model

Design Language—Caladine's Learning Activities Model (LAM)

Caladine's (2003) model (Figure 3) focuses on *material* "to differentiate between human and non-human resources" (Caladine, p. 126) and described aspects that are provided for, or delivered to, the learner.

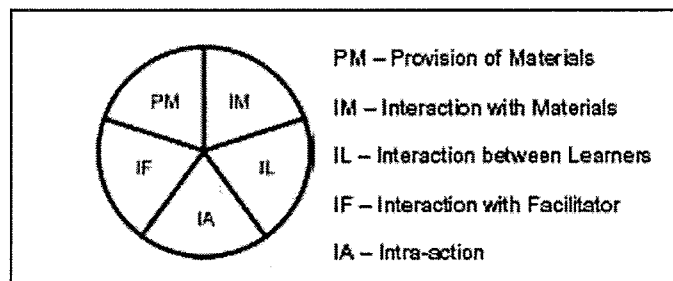


Figure 3. The Learning Activities Model of Caladine (2003)

All other components of the model deal with *interaction* as defined by “reciprocal action” (Caladine, p. 130). The entire circle represents the collective components of all activities that may be associated with learning, not just those designed in a formal sense. One purpose of the model is to provide a framework for “the analysis of planned or existing learning events” (Caladine, p. 139). The author has selected the Caladine (2003) model as a reflective analysis tool to apply to the class studies in simple table form (Figure 4) for purposes of class comparison. Given that the model does not overtly identify activities, designed or otherwise generated by students, it has the potential to capture a broader perspective on class experiences.

<u>Caladine Component</u>	<u>Class A</u>	<u>Class B</u>
PM – provision of materials		
IM – interaction with materials		
IF – interaction with facilitator		
IL – interaction with learners		
IA – intra-action		

Figure 4. Author’s application of the Learning Activities Model of Caladine (2003)

Both models can be applied in a granular way at the lesson, activity, or module level. The Caladine model increases awareness of particular patterns of interaction with others and provision of materials (resources and supports). The AUTC model puts the prime focus on the *design* of learning tasks that will hopefully engage learners—all other resources and supports flow from this. For clarity of class case presentation, the contextual details will be presented under the author’s headings that framed class data collection and initial thematic analysis (Brown, 1997).

CLASS STUDIES

Two classes conducted in 1994 incorporate student learning through construction of interactive multimedia (Table 1). The focus of the two classes is content acquisition within a thematic approach for deeper understanding, personal relevance, and authentic experience. Detailed data sets are published as a personal account in a doctoral thesis (Brown, 1997). The author was participant teacher and researcher, codesigning activities, developing

resources, and providing supports for two groups of students with dramatically different learning needs, interests, and motivation that brought to bear on them as multimedia authors. The data gathered included detailed notes on class plans, observations, student work, student interviews and surveys, video recordings of presentations and all multimedia artefacts developed and synthesised in the researcher's electronic portfolio that accompanied thesis submission as data for examiners to access.

Table 1
Aim of Multimedia Construction in Two Class Cases

Environment	Aim of Multimedia Construction	Construction Tools	Groupings
<i>G&T Class</i> Primary school students	Develop content knowledge through a process focus. Deep understanding of content constructing multimedia to learn	HyperStudio® (Lecturer took responsibility for scanning and video digitising.)	Individual, collaborative or cooperative.
<i>EDUM Class</i> Preservice primary school teachers	Develop content knowledge through a product focus. Deep understanding of content through the design of a multimedia product to teach others	Word, HyperStudio® HyperCard® SoundEdit Pro®, PhotoShop® Video Digitising and Scanning software	Individual or cooperative.

Through thematic analysis of class and diary notes, interviews with co-teachers, and synthesis of student work in class sets for access and annotation, the following accounts have been distilled. In keeping with the structure recommended by Goodyear (2005) for communication of class cases, the author's teaching philosophy aligns with a constructivist approach; the "high level" pedagogy is collaborative design; the pedagogical strategy is group multimedia construction and the pedagogical tactics vary with each class, according to the context, particularly the presence or absence of a key driving force—assessment. The educational setting will be described under the key headings of context and tasks, people and interactions, concrete materials (technology infrastructure, media production resources and support tools) and anticipated process outcomes.

Gifted and Talented (G&T) Class: Elementary Students With a Process Focus

Class context and tasks. The first class comprised 22 gifted and talented students (G&T) drawn from nine local primary (elementary) schools. They met one day per week for creative extension work, and their principal teacher wanted to incorporate a computer-based activity into the daily plan. This occurred for 27 weekly sessions from April through to November 1994. There was no formal curriculum or mandatory assessment for the computer-based component.

People and interactions. A team teaching approach was taken with this group. In addition, a volunteer parent offered time, use of video equipment, and considerable video production expertise on eight occasions. The computer hour was "flexible" (additional time was subject to availability) and structured to enable students to express themselves using voice, acting and written expression. They produced a range of their own resources—video, sound, images, and text—for computer coordination, working with computers singly, in pairs, and in small groups. Peer tutoring was common as students developed skills using HyperStudio as a multimedia construction tool on a *need to know* basis. The teachers' role was to model and assist the development of problem-solving strategies with hardware and software, facilitate student group formation and functioning for a project according to topics of mutual interest, and to reflect student ideas back to the class at the commencement of each session. Teacher support was directed towards effective collaboration and discussion of strategies, and the creative process, rather than product quality. The tone of the whole day was creative extension work, therefore a unique opportunity arose to allow the students to freely explore HyperStudio as a cognitive tool for thinking and expression, and remain centred on what interested them for as long as they wished.

Concrete materials. Technology infrastructure: A range of Apple computers of the Colour Classic and LC models was used for multimedia production during the 27 classes. Machine numbers ranged from six to eleven. All computers in the laboratory were named and easily identified by large stickers. Although laboratory machines were networked through Appletalk®, this facility was too slow to move files. Due to limited hard disk space students could not store their work on the machines. Backup was to two floppy disks per student. Two external hard drives supplied backup storage of group project resources as the volume of project material increased rapidly.

Media production resources: Audiovisual production was achieved using a VHS video camera with tripod, an Ion Camera, and a tape recorder. Students created their own video clips and audio files. They sought much of their information and many images from books, collector cards, calendars, and magazines. The “props” room next to the classroom provided many costume resources for video production. When direct sound recording at the computer was not an option, groups used the tape recorder as an intermediate storage and testing device. In some cases sound production was scripted and rehearsed, and in others it was a matter of spontaneous production.

Support tools: Those generated by the teacher were of print, video, and software nature. The print support tools included individual student skill checklists, work sheets to stimulate brainstorming of ideas through the alphabet and across the interrogatives (who, what, why, where, when, how), and folders and envelopes to store individual and group resources. Several software tools were produced in HyperStudio and in HyperCard.

Anticipated Process Outcomes. It was anticipated that due to the student-centred nature of this kind of computer production, the program structure would unfold in response to student needs. Few details could be preset—the interests and talents of the students would largely determine the content and duration of particular exercises. Ample scope was provided for exploration and extension of different talents. Students were not expected to selectively use computers for their projects, though it was anticipated computer-based activities would complement material dealt with throughout the program. In short, the anticipated process outcomes were broad media production, varied individual and collaborative exercises, student-selected topics, and rapid mastery of HyperStudio software.

EDUM Class: Preservice Teachers Given a Product Focus

Class context and tasks. This class (labeled EDUM for course code) was based within the Faculty of Education at the University of Wollongong. The students were preservice primary teachers studying an elective subject that would prepare them to produce interactive multimedia resources, and understand the production process in order to support their own students as producers. They required systematic skill development in multimedia production, theory on instructional design, repeat production cycles, the use of a range of applications and development of written and oral presentation skills for the purpose of outcome-focused assessment.

The assessed tasks included basic skills (tasks 1 & 2), an individual project (task 3) and a group project (tasks 4 & 5):

- *Task 1(20%):* Demonstrate expert status by achieving mastery in at least one element of each of the following two areas:
 - o video production, sound recording, or computer-based graphics;
 - o movie, sound, or image digitizing.
- *Task 2 (10%):* Complete an instructional task using HyperStudio.
- *Task 3 (20%):* Produce a HyperCard Stack using your own resources. This stack will demonstrate your abilities to combine sound, text, images, and movies into a curriculum project. A HyperCard template will be available for use. Please note the emphasis is on appropriate resource selection and presentation, rather than programming ability.
- *Task 4 (25%):* An instructional design statement for a group curriculum software project, which describes the processes to be employed, the proposed goals, instructional strategies, the need for the particular piece of software, and indicates how you will contribute to the product.
- *Task 5 (25%):* Implement a prototype of your group curriculum software. This prototype will have the basic structure and feel of the package but only the key structure will need to be developed.

People and interactions. Following a series of lectures on instructional design, students could experience the design process, peer tutor as a technique for assessing skill development, and familiarise themselves with a networked environment and its resource management implications. Subject components were structured to enable them to develop skills using a broad range of hardware and applications including two multimedia construction products—HyperStudio and HyperCard. Students were placed singly, in pairs, in small group and whole group formats to allow them to trial and acknowledge their response to collaborative work with computers. The teacher's role was to share class strategies with students (acknowledging their dual role as learners and future teachers), model, and assist the development of problem-solving strategies with hardware and software, and assess students. Mastery was used for skills and graded scales were applied to individual and group tasks.

Concrete materials. Technology infrastructure: For most classes there were 11 networked Apple Macintosh computers available for student production. Hard disk space was limited (40 Megabytes) on three machines, most had between 8 and 20 Mb of RAM, and all were linked by Ethernet to a file server with ample storage capacity.

Media production resources: Since students were required to develop audio-visual production skills they generated all their own resources using a Super VHS video camera with tripod, tape recorder, Ion Camera, Colour Scanner, and digitising board.

Support tools: Those generated by the teacher were of print, video, and software nature. The print tools included class activity sheets, detailed step-wise tutorial documents for HyperStudio and HyperCard, and HyperStudio exercises from "Hands on Multimedia for Teachers" and "Hands on Multimedia for Kids" (Abernathy, André, Bass, and Sonnenberg, 1993). Video was used for recording of live demonstrations, including student *Show and Tell* sessions. Several software tools were produced in HyperCard.

Anticipated process outcomes. It was anticipated that students would become proficient at digitising images, sound, and video, and would develop some concept of multimedia construction tools. HyperStudio was used as the first construction tool due to its simple interface and powerful functionality across colour graphics and animation. HyperCard was less user friendly in the early stages, but ultimately more powerful and flexible if scripted in HyperTalk. The progression within a software category from one commercial product to another was deliberate—aimed at enabling students to identify similarities and differences between products. It was hoped this would allow them to increase their flexibility with software and think more about multimedia construction tools as a concept, rather than overgeneralise from one product. The broad range of applications used for media digitising was expected to enable students to develop confidence with such applications, experiment with options, and begin to select appropriate applications for different self-generated tasks and effects.

Similarities Across G&T and EDUM Classes

There were a number of common processes and process outcomes shared by students in both classes due to their active involvement with interactive multimedia as knowledge and product designers.

High levels of motivation and task engagement. Students were free to generate their own resources, and through discovery, discussion and reflection, they appeared to develop an appreciation for the relationship between media format and message fidelity. High quality graphics were a universal source of excitement, especially when they were scanned from personal photographs. When sounds accompanied images, creative freedom was expressed through humour and emotion. High task engagement was evidenced by extended periods of involvement beyond class.

Contextual problem solving and skill development. Skill development with production and construction tools occurred on an individual, paired and collaborative basis. Students could seek moral and technical support when they needed it, and focus on what they were good at first. Problem solving and extended skill development was anchored to the context of student-driven tasks, since in all cases students selected topics of personal interest and relevance.

Creative freedom with interface design. Creative freedom was expressed through media selection and individuality of interface design. Group collaboration was initially strong, as skills were new to all. This changed over time as different individuals developed their unique expert profile. Students were often immersed in the production of one screen (card), to the exclusion of any consideration of other related screens. They did not automatically standardise the placement or colour of screen elements, and even when principles of interface design were discussed, very little standardisation of screen elements occurred. Cultural freedom was evident as students chose their own topics and expressed personal attitudes and values. Screen design was highly emotive and individual, expressing more the nature of the producer than exhibiting awareness of or concern for a target audience.

Amplification of student differences. Although all students were engaged in similar tasks, their individuality was highlighted as hidden talents were discovered. There were orators, artists, poets, writers, actors, animators, and directors. Each class provided students with the opportunity to explore untapped talents. Plagiarism was not a concern. While students expressed enjoyment at the ability to use a graphic, which they could not have produced themselves, it was not presented as their own work. These graphics inspired further production resulting in a unique orchestration of media. Students wanted to “add their own flavour,” and often did so with sound, captions, or video clips, frequently peppered with humour. The concept of originality related to style of media compilation.

Evidence of higher-order thinking. Through interactive multimedia production and construction, students were able to demonstrate the characteristics of higher-order thinking described by Resnick (1987). They followed a non-algorithmic path, faced knowledge, skill and process complexity, generated multiple solutions, coped with uncertainty, demonstrated nuanced judgment with media selection and adaptation, were required to self-regulate their thinking, and put considerable effort into structuring information.

Need for flexibility. Teachers and students had to be flexible to respond to varying stages of student progress with tasks, incidental emergencies or the varied pace and content of group discussions. Peer support was a vital factor in maintaining class flexibility—students had to be able to give and take, share and care, explain and listen, encourage and accept support. They had to learn to plan their own tasks and seek help when they were stuck. For some students this level of self-regulation was their biggest challenge. The relationship between the students and teacher/s was crucial to the success of classes—mutual respect was very important, so expectations placed on students had to be met by teachers.

Rapid identification of limits of technology. Students in all classes exhibited frustration with the limitations of the available technology, once they became aware of multimedia production possibilities—they rapidly expanded to fill available space. The G&T class quickly reached the limits of hard disk storage and RAM, and had great difficulty moving large projects. EDUM students were sometimes frustrated with network speed and disappointed with digitised video quality, considering its production was time-consuming and complex. Yet students in the main were very tolerant of variations in image and sound quality.

Although there were similarities that reflect the experience of working with multimedia construction tools, the differences between classes were marked with regard to the nature, importance, and orchestration of resources. To some extent this reflected the difference between students as *multimedia production* experts (EDUM class) who had to produce an assessable product within a deadline, and students as *knowledge construction* experts (G&T class) who freely explored a knowledge domain and stored their trail as multimedia snippets on the computer.

Differences Between G&T and EDUM Classes

Students in G&T and EDUM classes were distinguished by the absence or presence, respectively, of formal assessment as a requirement. That sharp contrast had an impact on the *motivation* behind production and the relative freedom students had to set time frames.

Process focus: For the G&T class, the emphasis was placed on learning that occurs through the *process* of interactive multimedia construction—“learner as designer” (Jonassen & Reeves, 1996). There was no pressure applied regarding the nature of the product—it was considered far less important than the knowledge construction process (journey, not destination). There was less concern about refinement of particular production skills and more emphasis placed on student-initiated design and development with just-in-time skill support. The cognitive load of the construction tool was low to allow the learners to focus on knowledge construction.

The emergent process outcomes of this class are represented in Figure 5 as an author adapted AUTC learning design timeline. It shows there were two key tasks for students—the first an individual one relating to basic skill development in an exploratory way, and the second a group project that occupied students intermittently for many weeks. Most supports shown in Figure 5 were teacher generated and distributed throughout the timeline in keeping with just-in-time support. Resource provision was shared equally—for teaching staff the main emphasis was on hardware/software and props for video production. Students sourced their own material for thematic projects.

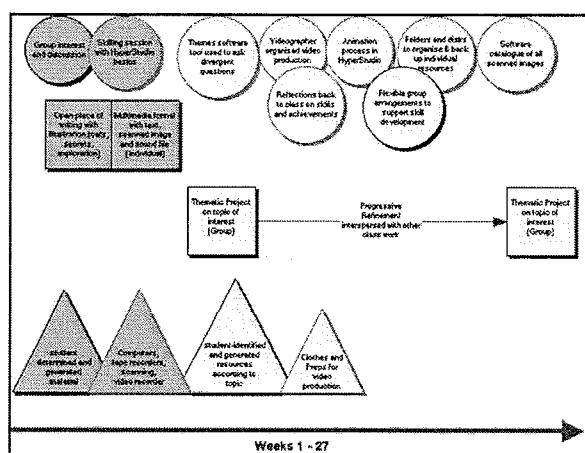


Figure 5. Resources, activities, and supports in the G&T class timeline

The unique process outcomes for students in the G&T class included:

- support from both peers and a team of teachers who were able to complement each other and respond to needs as they arose
- self-determined nature and pace of skill development with computers
- little concern with how to use a production tool and more focus on what could be done with it (for example animation tools in HyperStudio®)
- limited computer laboratory time (less than one hour per week)
- extended involvement in a topic of personal interest supported by flexible group arrangements
- optional use of audio and video production if and when appropriate to a project
- focus on content research, resource production and individual screen design rather than overall program structure (bottom up approach)
- demonstration of cognitive flexibility—when one idea didn't work students were willing to drop it and try another

Product focus: For the EDUM class, the emphasis was placed on the development of an interactive multimedia software *product*—“designer as learner” (Jonassen & Reeves, 1996). The key body of knowledge to be digested was interactive multimedia production, along with a set of skills. This was a situated and authentic activity, but it relegated content knowledge related to a particular project to fringe benefit status. Frequently the cognitive load of the production tools was high. The emergent process outcomes of this class are represented in Figure 6 as an author adapted AUTC learning design timeline.

It shows the existence of parallel tasks for students due to the range of skills required for product development—skills not only in digitising resources but skills developing proficiency and some degree of technological fluency with multimedia construction tools. Students had three clusters of tasks that developed interrelated skills in an iterative fashion, and grouped them individually, in pairs, and in large groups. Teachers supplied most supports, provided when students were required to develop new skills. Student peer support emerged as their skill levels rose. They also took over development or provision of resources as they consolidated skills, explored their creativity, and engaged with project topics.

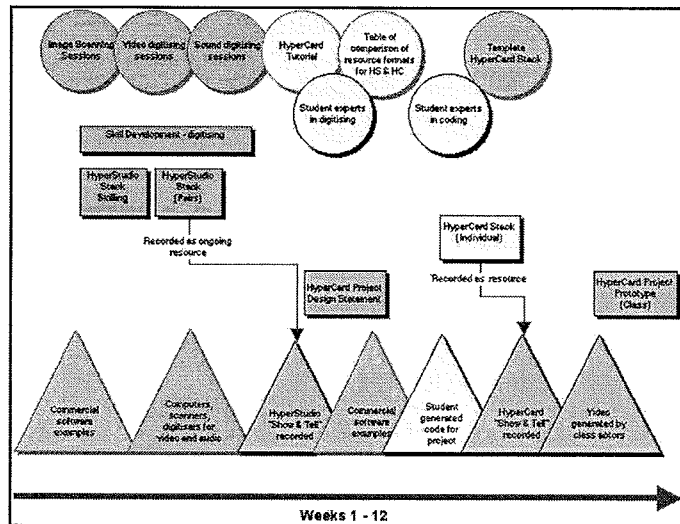


Figure 6. Resources, tasks, and supports in the EDUM class timeline

The unique process outcomes for students in the EDUM class included:

- refinement of production skills through the process of teaching peers
- high self-esteem associated with the development of multimedia production skills that were considered novel but also valuable
- developing awareness of multimedia authoring tools as a software category
- substantial time in the computer lab (minimum of three hours per week)
- concern expressed over assessment criteria as a measure of "success"

Table 2 shows the analysis of both classes according to the Caladine (2003) Learning Activities Model with the emphasis on interaction. Students not bound to rigid timetables for assessment (process focus) were free to drive the nature and extent of their interaction with materials, free to drive the direction of the class activities according to their needs and the emerging skills and talents identified by the facilitator, and this relative freedom permitted highly flexible peer interaction, tutoring, and mentoring. In contrast, the students given a product focus were required to develop much higher levels of production skills, and this demanded more resources and supports.

Student grouping was much less flexible even in the large project, since it was necessary to divide the negotiated tasks to reach completion. Certain students needed to adopt specialist roles while others were required to apply their relative expertise for the “good of the project” rather than develop skills they may have been initially lacking.

Table 2
Analysis of Class Activities Using the Caladine (2003) LAM

Caladine Component	G&T Class (Process focus without assessment)	EDUM Class (Product focus multiple assessments)
PM – provision of materials	Mainly supports in accordance with student identified needs.	Mainly supports in accordance with specified assessable tasks.
IM – interaction with materials	Student driven as students determined the resources. Students selected animation, video role-play, audio-only interviews and detailed artwork (scanned) where appropriate to their needs. Limited laboratory access.	Heavily guided by specific tasks with multiple supports, templates, “show and tell” sessions that were recorded for future reference and extended laboratory access. Students had to engage with a wide range of materials.
IF – interaction with facilitator	Highly flexible driven by student needs; teacher reflects student achievements at beginning of next class and models file and resource management strategies. File backup by teacher provides overview of student progress and identifies expertise.	Lecturer dependent initially due to task driven timetable and limited production expertise; more a facilitation role as major group project progressed.
IL – interaction with learners	Encouragement of peer mentoring with flexible team arrangements; team member absenteeism not a problem with this flexibility. Interaction with other class projects extends computer time to integrate with other work and link other themes to project topics selected by students.	Varied student groupings across designated tasks. Free student interaction once the major project was the focus. Enhanced creativity evident in resource production phase of major group project.

Table 2 continued

IA – intra-action	Evident in student driven progressive task refinement and access to peers for advice from "resident experts". Also assessed via student comments at initial reflective sessions.	Students reflected and shared insights, highlights and failures at key "show and tell" sessions. These were vital to link concepts using different production tools.
-------------------	--	--

The process outcomes for students of G&T and EDUM classes demonstrate advantages for learners engaged in multimedia construction/production. When conducted in a face-to-face environment, it facilitates the development of a wide range of associated social, technical and problem-solving skills, permits knowledge representation in a range of media forms, and allows the learner to engage in a relatively long-term process.

DISCUSSION

Issues for Teaching Staff

Positioning on the process to product continuum. The benefits of multimedia construction are tempered by a number of related concerns when an extreme approach is adopted. Table 3 identifies the characteristics of an extreme product or process focus, and illustrates what could exist in an intermediate zone according to criteria determined by the author.

With a pure product focus, unless a learning environment is specifically geared to teaching commercial multimedia producers to apply their knowledge immediately, this skill set is likely to join the ranks of inert knowledge and date quickly due to the rate of development of production tools. Since the client or target audience frames the nature of a product from its outset, students typically discard material that is not relevant to their needs. Hence the body of knowledge within the product is frequently too specialised for repurposing. Rich activities for learning—such as student recording of information surrounding the nature and purpose of the task and the rationale for media selection, or student organisation of the primary resource set for future access, would be seen as distractions competing with the task goal.

Table 3
Criteria Used to Define the Product/Process Continuum

Criteria	Extreme product focus	Intermediate zone	Extreme process focus
Point of Emphasis	End point, with no regard for process beyond its necessity	Journey and end point	Journey, rather than an ultimate end point.
Goal	Prespecified by external forces; known at the beginning	Negotiated with learners as they become task aware	Developed by the individual or group over time; may keep evolving
Media selection	Often prespecified by "client" needs or costs	Selection by learners after exploratory phase	Media explored and compared by the constructor
Concern for Individuals	Minimal apart from their ability to generate the product.	Balance between individual journey and group output	Paramount—the richness and nature of team experience matter most.
Record keeping	Focused on product—resource lists, design drafts, user testing details	Individual journals and stages of any group product	Experience of team members, reflections on personal issues, emotional issues, resources collected
Reflective analysis	Production techniques; product structure and publishing features; feedback from goal setter	Teamwork, what individuals have learned, peer analysis of products; design guidelines for further products.	Process, teamwork, learning strategies identified, content knowledge; what you would <i>now</i> publish.

If assessment criteria relate purely to the product, they fail to capitalise on those broader and more personally meaningful outcomes for different students in a group situation. The easy option is to anchor assessment criteria to a formula of components or checklist approach. While this deals with a competency approach to skill development, it fails to acknowledge much of the higher order thinking associated with a complex blend of de-

sign, functionality, message, and purpose. To maximise content processing and structuring, students should be specifically skilled to a template or design framework (Wilhelm, Friedmann, & Erickson, 1998) associated with their assessment.

If a pure process orientation is taken, emphasis is placed on the individual's journey, media production is purely exploratory, and records focus on emotionally bound issues. Without some self-identified goal driving internal motivation, a student may well choose not to engage with the process. Compounding this, if students have poor metacognitive skills and are unable to self-monitor, organise, and self-regulate, no learning goal is likely to emerge. Lack of concern for the "end-point" of multimedia construction may relegate its usefulness to the level of a throwaway work sheet. Students may not value or develop an understanding of why they should store the resources they generate. The construction process may be regarded as pointless, unless the knowledge gained can be manifest and assessed in other ways they find personally meaningful. Students should be encouraged to retain the snippets of their construction trail along with annotations of resource source and thoughts linked to their selection.

Neither the process nor product extreme capitalise on one of the key benefits of computer-based technology—the ability to store, revisit and repurpose material so that an evolving body of knowledge can be visualised. Nix (1990) alluded to this with reference to the computer as "decentred participant," orchestrating the overall product to share with others. Through the experience of the G&T and EDUM classes, the author gained an appreciation of the complexity and versatility of the instructional strategy of learning through multimedia construction.

The mid-range options of Table 3 decentre the computer, establish challenge goals with students and clarify the purpose, assessment components and marking criteria for multimedia construction. Assessment should be aimed at a range of outcomes in addition to the product. Ivers and Barron (1998) stressed the importance of making students aware of the criteria that will determine their grade, and suggested the use of checklists or rubrics at each phase (decide, design, develop, evaluate) of their project approach to multimedia. Jonassen, Peck, and Wilson (1999) supported the use of rubrics as a source of information to improve performance, with some key qualifications. The scales for each complex performance element should consist of ratings that comprehensively describe different levels of performance, yet these ratings should not be associated with scores that are compiled for a grade.

Skills required. The author found prior knowledge of multimedia project work as an instructional designer (Hedberg, Harper, & Brown, 1994) was useful to support the problem-solving aspects of free student-driven construction in the G&T Class, and the technical knowledge required for lectures on design and skill development in the EDUM Class. However, it was inadequate preparation for many aspects of a student-centred classroom that encourages students to engage in multimedia construction. Having production and problem-solving skills yourself does not automatically translate into skills managing others in the production seat for learning.

As a teacher in a technology rich environment since 1994, the author has progressively tackled stages of self-awareness. The initial role in survival mode was driven by pragmatics—referred to as learning environment manager. The focus was on technical issues, file management, and class flexibility (Brown, 1998). Over time, the reflective practitioner was evident with a focus on observation, analysis, and student feedback to allow pedagogical strategies to emerge from intuitive tactics for sharing and discussion with colleagues. One particular strategy was to acknowledge the transition from learner to manager, designer, and researcher (Brown, 2002). The next phase was learning designer, with a focus on balance of activity design to increase student-centred learning. This represents the opportunity to support colleagues who need not reinvent the wheel, and who increasingly work in an environment of team design and implementation (Bennett, Brown, & Lockyer, 2003). It took several years to fully appreciate the role of computer as decentred participant (Nix, 1990).

Strength of teacher/facilitator/team factor. The concrete environment is far less important than what activities occur within it. The teaching team set the class expectations and tone, and their strength is in making the most of what they have available. Students should bear much of the responsibility for multimedia construction, and they will over time if they are allowed to and if generic support structures are in place. However, those experiencing this for the first time should be prepared to weather some personal emotional storms as control is relinquished, and strategies are identified to handle the range of student entry-level skills with the technology. Coworkers need to share experiences and complement efforts. Sometimes it is a matter of “give before you receive.”

Vital nature of file management and information systems. File management with multimedia construction is critical. Students need to manage their

numerous files and multiple versions across storage sites (necessary for backup). Unless teaching or general support staff nurture them through the process, and help them to see the need to design their own information management system for project resources, students cannot be expected to gain the advantage they should from the experience. They should be developing their own style for organising, managing, and reaccessing past work. The principles of project integrity (all files where they should be and functional) and version control (each version is stored as a separate entity to re-access as required) ensure that students are heading towards technological fluency and long term benefits of the construction experience, that will transcend the class.

Value of activity or learning design models to focus on different aspects of task design. Teaching staff each constructs a unique understanding of the process of task design (if in fact it is even explicit at all) and a language for this is still emerging. It is common to inherit assessment tasks with minimal context for their rationale, and policy constraints may limit short-term flexibility to adjust many aspects of a subject. There is value in looking at different models (Agostinho et al, 2002; Caladine, 2003) to improve aspects of a particular task or the balance of tasks within a subject or module. There are essentially three aspects to address—the learning tasks, the concrete environment provided and the way people interact. Typically teaching frustrations rest with the fact that many decisions regarding the concrete environment are not easily controlled. However, tasks and interactions can be adjusted to maximise student engagement through more authentic activities.

Value of multimedia construction to support generic skill development. In developing an instructional framework to support generic skill development that features deep learning through student-centred activities, Luca and Oliver (2002) emphasised process rather than a content focus. They identify from the literature:

Three encompassing elements which appear to be consistent within the majority of researchers' descriptions include a need for settings: to encourage and promote self-regulated learning; to support and encourage reflection among learners; and to demonstrate degrees of authenticity and relevance of the content and learning processes. (p. 2)

The design process adopted is identification of learning objectives and assessment criteria, choice of a learning design such as problem, case, proj-

ect or inquiry-based learning, then development of three types of tasks—authentic, self-directed, and reflective ones. These are then complemented with online resources and supports. Resource examples include QA procedures and templates, past student projects, and online weekly briefs. Support examples include tutor advice, online tutorials, and project briefs describing client needs. The following sample quotes illustrate the philosophical tone of the class:

It was intended that learners be required to make their own decisions about which activities they would perform, share ideas and then actively reflect on the results.

Self-regulation was promoted by allowing students to make free and open choices about a range of different learning tasks, including project topic, team members, their team roles and responsibilities. (Luca & Oliver, 2002).

It would be easy to incorporate a multimedia construction task in a subject or module as an authentic, self-regulated, or reflective activity, and not unusual with more of a process emphasis to feature all three components in the one rich and authentic activity. Given their need for a more self-regulated learning approach, it is important to consider the multiple issues the students may face.

Issues for Students as More Self-Regulated Lifelong Learners

If engaged in any form of multimedia construction, students will potentially carry a considerable responsibility, and should be made aware of the following considerations. Given the emphasis on higher order thinking fostered by an extreme process or product approach, it is important to make sure they have clearly identified assessable outcomes and their criteria communicated to them.

Multimedia construction is complex and generative. The complexity of multimedia construction initially seems considerable, no matter how simple each tool, and it demands the development of metacognitive skills to produce any kind of functional product or polished presentation. A diverse range of production or resource handling skills are required in a relatively short time frame, which is great for the development of problem-solving strategies, and student self-awareness of their learning style under these conditions. Students need to be idea generators as well as analysts. Some may not like such creative freedom, and may struggle to commit to a personally meaningful challenge.

It is well worth the emotional angst at this stage, as long as students can reflect on the positive growth when they reach their destination, and generate alternatives from negative issues. Tactics to assist idea generation, clustering, and representation are very important activity primers.

Diverse learning styles affect team skills. The obvious differences in learning and thinking styles among class members will have a substantial impact on group activities, so the arrangement of individuals in groups needs to be carefully considered. Rather than attempting to match student profiles to particular roles or groups, it may be far more beneficial to vary the types of group experience so learners broaden their concept of group work.

If assessment methods are geared to cater for both individual and team processes and products, this will generally ease student concerns about fair play since it acknowledges that group performance won't happen without individuals, and allows them to assess their performance as an individual, team player, and knowledge constructor. If roles are set for students, then learning style differences suggest only a certain proportion will naturally possess the skill set to comfortably achieve what is requested. Since other students are set up for discomfort, the learning goals should be clearly explained so students understand what they may gain from the pain.

If the emphasis is on team performance, and product development is an exercise to foster team skills, that should be made very clear to students, and the lessons learned from the product development should be assessed in alternate ways. Although students may be able to list team skills and describe the functionality associated with different roles, they need to experience them, reflect on their performance, and set themselves goals for further improvement. Clear understanding of the purpose of group work, what knowledge is to be gained and how that will be assessed is vital.

Peers should be acknowledged as experts and critical friends. The vast array of skills required for either individual or group multimedia construction suggests "jack of all trades, master of none" is no longer achievable. The alternative is that while students attempt to learn a wide array of skills, they may gain more if they are able to specialise to some degree and offer their relative expertise to the group. Multimedia construction requires many expert hats, such as technical, organisational, interpersonal, creative, or content. That favours the establishment of a collaborative environment for the whole group, within which cooperative teams may function.

Between group competition does not maximise learning for all—it merely deprives groups of access to experts and critical friends. Students

need to develop the ability to constructively criticise peer work. One simple rule to follow is “don’t knock it if you can’t suggest an alternative.” When student work is published prior to the due date, peer review at this stage prompts awareness of role reversal (user/producer), so students learn through the constructive criticism they offer others, and new views of their own work when they return to it. The opportunity should always be provided for last minute improvements to maximise the benefits of peer review, and familiarise students with the iterative nature of design.

Support for students should be both central and distributed if possible.

Student support should be able to channel the energy of their enthusiasm on a need basis, offering conceptual, technical, and emotional guidance. This redistribution of staff time and priorities may necessitate changes in teaching load, profile of support staff, or the development of teaching teams to capitalise on different areas of relative expertise.

Distributed support throughout a degree may come from small module-based teams focused purely on subject specific tasks. Curriculum mapping is important to maximise the staffing efficiency of this method. Central support would allow students to independently develop a professional portfolio across all relevant activities—not just those identified as key assessable tasks. If considering this, support staff may well be scattered through faculties and central units such as IT, library and learning development. This represents a much more significant level of institutional backing, as it will typically involve substantial online and CD-ROM based generic resources and an expectation that students will accomplish significant technological fluency as one of their graduate attributes.

Multimedia construction is an excellent process to enable portfolio compilation.

There is no magic portfolio structure—students need to manage a personal information system in order to create and save annotated pathways through their collection for different audiences. The real benefit of maintaining a collection of individual and collaborative works is to permit reflection, and when required, illustrate not only attainment of generic skills for tertiary students, but also content specific knowledge and problem-solving capabilities in the context of personal values and philosophies.

This portfolio compilation style process is equally valid for both students and staff as lifelong learners—as all need to monitor performance, collect artefacts, tag these according to key words and potential audience, then reflect, analyse, select, and gear collections for different purposes. Purposeful pathways through the past allow learners to identify the distance

and direction travelled. Teaching academics need to experience this ongoing process to appreciate the skill set their students are developing. Thus the toolset for teaching is also the potential toolset for self-regulated teaching staff career monitoring and planning.

Although not all teaching staff need sophisticated ICT skills to productively integrate multimedia construction in their teaching and learning environment, they do need to understand the metacognitive aspects of production, to offer students appropriate guidance, and they do need access to technical support. Since there are intricacies associated with different tools, the way to develop sophisticated mental models of learning associated with these different cognitive tools is immersion in their use with varied classes and activities over a prolonged period. The larger the support team that share this knowledge, the greater the flexibility in support structures that can be offered as long as student needs are repeatedly canvassed. Realistically, multimedia construction is no longer an activity that should be considered in isolation within a module or subject.

CONCLUSIONS

When students are given creative freedom to construct with multimedia tools in an activity that is personally meaningful, they exhibit high levels of motivation and task engagement, develop skills through directed and needs driven episodes, exhibit higher order thinking, and individual differences are valued, accentuated, and expressed through interface design. These classes demand considerable flexibility from all participants, particularly as the limits of the available technology are identified.

What the G&T and EDUM classes illustrated was variation in the purpose behind multimedia construction, its alignment with assessment, and its progressive integration with a range of complementary activities in the learning environment. With time and experience, multimedia construction has been conceptualized as a learning design, rather than a discrete product or project-related activity. When considering the relative value of process or product for assessment, it is important to view student challenges in a broad context. On high power objective, with multimedia construction in focus, it may be tempting to simply assess the product of construction. Switching to the low power objective brings other parallel activities into sight, and may help designers to consider ways to value and highlight process over an extended time frame.

From the student's perspective, challenges should not be seen as isolated and inert parcels of knowledge. The process focus is ideal for initial

exploration of construction tools, but it is also vital as the foundation beneath intermittent product publishing. As students complete knowledge construction activities, their accumulation of electronic files (past tasks) will begin to lose coherence. To construct their own “big picture,” they must be encouraged to reflect, review, and experience the demanding process of restructuring work to incorporate new information. The inner processes of assimilation and accommodation can be externalized if lecturers request synthesis of past work. For students, simple multimedia construction tools can still provide them with deeply engaging and sustained activities, as long as they are actively involved, have ownership of the challenge, understand its purpose, and can negotiate the assessment criteria.

Online learning environments provide opportunities to turn different kinds of interaction into resources and supports for members who may subsequently join a learning community. They also generate many elements that might be dismissed as “part of the process” yet may be some of the most meaningful elements learners can capture and share in their portfolios. Interactions among learners, with facilitators and annotations on materials provide powerful insights into thought processes that may never appear in a polished product, but sow the seeds of future big ideas.

If portfolio ownership is to reside with the lifelong learner, then we need to break down the barriers between formal and informal learning. Currently the technical constraints sit with tools, storage mechanisms, and file formats that can be preserved through time. These are also matched by financial and social constraints including equity of student access to fundamental levels of technology. Unless the pedagogical benefits and pitfalls are included in any discussion, decisions that are made on the purchase of tools, nature of technological infrastructure, and ongoing links with student cohorts as a learning community are missing an important perspective that might help to balance debate regarding where, when, and to what extent to feature a learning strategy like multimedia construction.

References

- Abernathy, B., André, D., Bass, A., & Sonnenberg, J. (1993). *Hands-on multimedia for kids*. Carpentersville, IL: MediaTech.
- Agostinho, S., Oliver, R., Harper, B., Hedberg, J., & Wills, S. (2002). A tool to evaluate the potential for an ICT-based learning design to foster “high-quality learning”. *Winds of Change in the Sea of Learning: Proceedings of the 19th ASCILITE Conference*. Auckland, New Zealand: UNITEC Institute of Technology. Retrieved February 18, 2007, from <http://www.ascilite.org.au/conferences/auckland02/proceedings/papers/164.pdf>

- Australian Universities Teaching Committee (AUTC, 2003). *Products of the AUTC project on ICT-based learning designs*. Retrieved November 30, 2003, from <http://www.learningdesigns.uow.edu.au/index.html>
- Bednar, A. K., Cunningham, D., Duffy, T. M., & Perry, J. D. (1991). Theory into practice. In G. J. Anglin (Ed.), *Instructional technology past, present and future* (pp. 88-101). Englewood, CO: Libraries Unlimited.
- Beichner, R. J. (1994). Multimedia to promote science learning. *Journal of Educational Multimedia and Hypermedia*, 3(1), 55-70.
- Bennett, S., Brown, C., & Lockyer, L. (2003, May). *The evolution of teaching and learning over seven years of on-line program development*. Paper presented at the International Conference on Network Universities and e-Learning: Model for a European Networked University for e-Learning, Valencia, Spain.
- Biros, J. (1990). The use of HyperCard on a university campus. In S. Ambron, K. Hooper, & Apple Computer Inc. (Eds.), *Learning with interactive multimedia: Developing and using multimedia tools in education* (pp. 287-296). Redmond, WA: Microsoft Press.
- Bradsher, M. (1990). The teacher as navigator. In S. Ambron, K. Hooper, & Apple Computer Inc. (Eds.), *Learning with interactive multimedia: Developing and using multimedia tools in education* (pp. 311-329). Redmond, WA: Microsoft Press.
- Brown, C. A. (1997). *Learning through construction of interactive multimedia*. Unpublished doctoral thesis, University of Wollongong, NSW, Australia.
- Brown, C. A. (1998, December). Generic class management strategies for an education lecturer in IT. *Proceedings of the 15th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education* (pp. 107-120). Wollongong, NSW, Australia.
- Brown, C. A. (2002, March). Simple and effective—Teacher roles remain a powerful framework to embed ICT within the practice of teaching. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2002* (pp. 1252-1256), Nashville, TN. Chesapeake, VA: Association for the Advancement of Computing in Education.
- Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18(1), 32-41.
- Caladine, R. (2003). *New theoretical frameworks of learning activities, learning technologies and a new method of technology selection*. Unpublished doctoral thesis, University of Wollongong, NSW, Australia. Retrieved April 25, 2005, from <http://www.library.uow.edu.au/adt-NWU/public/adt-NWU20040921.114720/>
- Campbell, R., & Hanlon, P. (1990). HyperCard: A new deal in the classroom. In S. Ambron, K. Hooper, & Apple Computer Inc. (Eds.), *Learning with interactive multimedia: Developing and using multimedia tools in education* (pp. 257-286). Redmond, WA: Microsoft Press.

- Durrell, B. (1990). Understanding classroom computers: Student and teacher perspectives. In A. McDougall & C. Dowling (Eds.), *Fifth World Conference on Computers in Education - WCCE 90*, (pp. 757-762). Sydney, Australia. Amsterdam, The Netherlands: Elsevier Science Publishers B. V.
- Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australasian Journal of Educational Technology*, 21(1), 82-101.
- Hedberg, J. G., Harper, B. M., & Brown, C. (1994, February). Information landscapes and exploratory user interfaces: Redesigning to improve learning outcomes. *Proceedings of Selected Research and Development Presentations at the 1994 National Convention of the Association for Educational Communications and Technology* (pp. 247-257), Nashville, TN.
- Hofmeister, J. (1990). The birth of HyperSchool. In S. Ambron, K. Hooper, & Apple Computer Inc. (Eds.), *Learning with interactive multimedia: Developing and using multimedia tools in education* (pp. 199-221). Redmond, WA: Microsoft Press.
- Ivers, K. S., & Barron, A. E. (1998). *Multimedia projects in education*. Englewood, CO: Libraries Unlimited.
- Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning with technology—A constructivist perspective*. Upper Saddle River, NJ: Prentice-Hall.
- Jonassen, D. H., & Reeves, T. C. (1996). Learning with technology: Using computers as cognitive tools. In D. H. Jonassen, (Ed.), *Handbook of research on educational communications and technology* (pp. 693-719). New York: Macmillan.
- Kacmar, C. J. (1993, June). Hypermedia system functionality: Strategies for entangling users. In H. Maurer (Ed.), *Proceedings of ED-MEDIA 93—World Conference on Educational Multimedia and Hypermedia* (pp. 272-278), Orlando, FL. Charlottesville, VA: Association for the Advancement of Computing in Education.
- Liebhold, M. (1990). Hypermedia and visual literacy. In S. Ambron, K. Hooper, & Apple Computer Inc. (Eds.), *Learning with interactive multimedia: Developing and using multimedia tools in education* (pp. 99-110). Redmond, WA: Microsoft Press.
- Luca, J., & Oliver, R. (2002). Developing an instructional design strategy to support generic skills development. *Winds of Change in the Sea of Learning: Proceedings of the 19th ASCILITE Conference*, Auckland, New Zealand. Retrieved February 18, 2007, from <http://www.ascilite.org.au/conferences/auckland02/proceedings/papers/073.pdf>
- Nix, D. (1990). Should computers know what you can do with them? In D. Nix & R. Spiro (Eds.), *Cognition, education, and multimedia: Exploring ideas in high technology* (pp. 143-162). Hillsdale, NJ: Lawrence Erlbaum.
- Oliver, R. (2004, December). Moving beyond instructional comfort zones with online courses. In R. Atkinson, C. McBeath, D. Jonas-Dwyer, & R. Phillips (Eds.), *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference* (pp. 713-723). Perth, Australia. Retrieved February 18, 2007, from <http://www.ascilite.org.au/conferences/perth04/procs/oliver-r.html>

- Oren, T. (1990). Cognitive load in hypermedia: Designing for the exploratory learner. In S. Ambron, K. Hooper, & Apple Computer Inc. (Eds.), *Learning with interactive multimedia: Developing and using multimedia tools in education* (pp. 125-136). Redmond, WA: Microsoft Press.
- Papert, S. (1991). Perestroika and epistemological politics. In I. Harel & S. Papert (Eds.), *Constructionism* (pp. 13-27). Norwood, NJ: Ablex.
- Resnick, L. B. (1987). *Education and learning to think*. Washington, DC: National Academy Press.
- Sanders, D. A., & Sanders, J. A. (1984). *Teaching creativity through metaphor*. New York: Longman.
- Stebbins, B. (1990). Using HyperCard in Apple classrooms of tomorrow. In S. Ambron, K. Hooper, & Apple Computer Inc. (Eds.), *Learning with interactive multimedia: Developing and using multimedia tools in education* (pp. 223-255). Redmond, WA: Microsoft Press.
- Wilhelm, J. D., Friedmann, P. D., & Erickson, J. (1998). Hyperlearning. York, ME: Stenhouse.
- Wilson, L. (1993, June). HyperLearning: Students creating with hypermedia. In H. Maurer (Ed.), *Proceedings of ED-MEDIA 93—World Conference on Educational Multimedia and Hypermedia*, (p. 656). Orlando, FL. Charlottesville, VA: Association for the Advancement of Computing in Education.